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(71) Applicant: **NEC CORPORATION**
Tokyo (JP)

(72) Inventor: **Fujimoto, Koichiro**
Minato-ku, Tokyo (JP)

(74) Representative: **Betten & Resch**
Reichenbachstrasse 19
80469 München (DE)

(54) Toll collection system capable of properly collecting a toll from a user without requiring any special equipment to be mounted in a vehicle

(57) A mobile terminal (20) for mobile communication transmits a radio signal carrying a terminal number and a particular dial number. Each toll lane (12) of a tollgate is provided with an antenna (121) for receiving the radio signal and a vehicle's class detector (122) for detecting the vehicle's class of an automotive vehicle (11). Each tollgate is provided with a terminal information receiving unit (13) and an interface circuit (16). Responsive to the radio signal from the antenna (121), the interface circuit (16) identifies as lane information an entry lane which the automotive vehicle (11) is entering and acquires terminal information corresponding to the terminal number by accessing the mobile communication exchange system (30). The terminal information receiving unit (13) receives the lane information and the terminal information for transmission to a data memory unit (14). On the other hand, the processing unit (17) acquires vehicle's class information from the vehicle's class detector (122). The processing unit (17) then prepares and stores in the data memory unit (14) passage car information containing the lane information, the terminal information, the vehicle's class information, and a passage time. A central processing computer (15) obtains from every tollgate vehicle passage data including the passage vehicule information and tollgate information to prepare toll charge data.

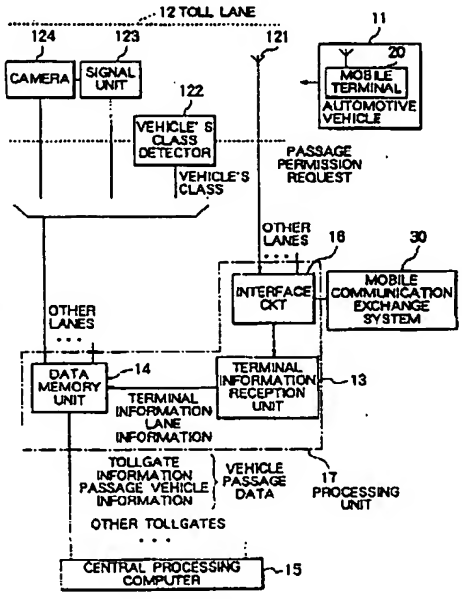

FIG. 1

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Description

Background of the Invention :

This invention relates to a toll collection system for a toll road, a parking space, or the like and, in particular, to a toll collection system for automatically collecting a toll from a user of a toll road by the use of radio signals transmitted between a tollgate and an automotive vehicle passing through the tollgate.

Traditionally, a road toll for a toll road such as an expressway is manually collected by temporarily stopping an automotive vehicle at a tollgate. In order to reduce time and labor of a user and a toll collector, proposal has been made of automatic toll collection systems each of which transmits and receives radio waves between data transmission/reception units equipped in both the tollgate and the automotive vehicle to acquire vehicle passage data, prepares toll charge data from the vehicle passage data, and automatically charges the road toll based on the toll charge data.

For example, one such system is disclosed in Japanese Unexamined Patent Prepublication (A) No. 242098/1993 which is called herein a first conventional toll collection system. In the first conventional toll collection system, an on-vehicle unit for toll collection is mounted in each automotive vehicle while each tollgate is equipped with an optical communication unit and a data terminal unit connected to a host computer. When the automotive vehicle approaches an entrance booth of one tollgate as an entrance tollgate, a tollgate number assigned to the entrance tollgate is transmitted from the data terminal unit through the optical communication unit in the entrance booth to the on-vehicle unit to be written in a memory of the on-vehicle unit as entrance place data. Then, the on-vehicle unit transmits to the optical communication unit registration number data, including vehicle type data, preliminarily registered. The registration number data and the entrance place data are delivered from the optical communication unit to the host computer through the data terminal unit.

On the other hand, when the automotive vehicle approaches an exit booth of the other tollgate as an exit tollgate, the entrance place data and the registration number data stored in the memory of the on-vehicle unit are transmitted from the on-vehicle unit to the data terminal unit through the optical communication unit in the exit booth. The data terminal unit transmits to the host computer exit place data representative of a tollgate number of the exit tollgate together with the registration number data and the entrance place data supplied from the on-vehicle unit. In response to those data, the host computer issues a toll payment order.

According to the above-mentioned first toll collection system, it is possible to collect the road toll, such as an expressway toll, with reduced load both on the user and the toll collector and without stopping the automotive vehicle at the tollgate.

Another toll collection system is disclosed in Japanese Unexamined Patent Prepublication (A) No. 120504/1993 which is called herein a second conventional toll collection system. In the second conventional toll collection system, each automotive vehicle has a portable responder for transmission and reception of toll collection data when the automotive vehicle passes an entrance part and an exit part of an expressway. When a credit card is inserted into the portable responder, the portable responder is enabled to transmit an ID (identification) code of the credit card, to store reception data in a memory as stored data, and to transmit the stored data.

When the automotive vehicle passes the entrance part, an entrance on-road unit receives the ID code transmitted from the portable responder and in turn transmits the ID code together with an input time of the ID code and an entrance tollgate name to a central unit. Simultaneously, the input time and the entrance tollgate name are also sent to the portable responder to be stored in the memory of the portable responder as the above-mentioned stored data. In the exit part, an exit on-road unit receives the stored data from the portable responder. The exit on-road unit then calculates the road toll and transmits required data, such as the road toll, an exit tollgate name, and a passage time, to the portable responder and the central unit.

In addition, each tollbooth is equipped with a signal unit and a camera to monitor illegal passage of any automotive vehicle.

The second conventional toll collection system is excellent in safety and reliability and enables smooth and efficient toll collection with a very small number of toll collectors.

Still another toll collection system is disclosed in Japanese Unexamined Patent Prepublication (A) No. 108916/1993 which is called herein a third conventional toll collection system. In the third conventional toll collection system, on each automotive vehicle is mounted an on-vehicle ID signal processing device for toll collection which includes an on-vehicle antenna, a place ID memory, and a vehicle ID signal generator. An entry ID signal processing device is installed at each entry gate of the tollgate for expressway while an exit ID signal processing device is installed at each exit gate of tollgate for expressway.

In the entry gate, the on-vehicle ID signal processing device receives via the on-vehicle antenna an entry ID signal for the tollgate for expressway and temporarily stores in the place ID memory the entry ID signal indicating where the automotive vehicle enters in the expressway. In the exit gate, the on-vehicle ID signal processing device sends an vehicle ID signal and the entry ID signal via the on-vehicle antenna from the vehicle ID signal generator and the place ID memory, respectively. The exit ID signal processing device receives and recognizes the these ID signals. Thus, an expressway rate is automatically calculated and processed by

a rate computing device using information of the exit gate of the tollgate for expressway and the above-mentioned ID signals.

However, the conventional toll collection systems described above are disadvantageous in the following respects.

Each of the first and the third conventional toll collection system is based on the presumption that the on-vehicle unit or the on-vehicle ID signal processing device preliminarily stores a correct registration or ID number assigned to the automotive vehicle. Collection of the toll is addressed to the vehicle registration or ID number stored in the on-vehicle unit or the on-vehicle ID signal processing device and the user himself is not specified at all. It is therefore difficult to quickly and accurately collect the toll. In addition, the cost of the automotive vehicle is inevitably increased by the equipment of the on-vehicle unit or the on-vehicle ID signal processing device. Smooth and non-stop passage through the booth and reliable toll collection are expected provided that all automotive vehicles are obliged to mount the on-vehicle units or the on-vehicle ID signal processing devices and actually equipped with the on-vehicle units or the on-vehicle ID signal processing devices. However, it is impossible to prevent occurrence of failure in the on-vehicle units or the on-vehicle ID signal processing devices, presence of unequipped automotive vehicles during a transient period, and illegal passage of those automotive vehicles from which the on-vehicle units or the on-vehicle ID signal processing devices are intentionally removed.

On the other hand, the second conventional toll collection system makes use of the ID code registered in the credit card carried by an individual. Accordingly, the user can be specified as a payer of the toll. However, the second conventional toll system is expensive because such special-purpose portable responder must be purchased in order to use the toll road. In addition, since a plurality of portable responders transmit and receive the radio waves in a very close range at the tollgate, it is difficult to discriminate among the portable responders, namely, the radio waves. Furthermore, it is impossible to identify the vehicle type of the automotive vehicle passing the tollgate. Thus, the second conventional toll collection system is practically disadvantageous.

Summary of the Invention :

It is an object of this invention to provide a toll collection system which is capable of properly charging a user of a toll road for a toll without requiring any special terminal unit to be equipped in a user's vehicle.

A toll collection system for a toll road to which this invention is applicable transmits and receives radio waves between a tollgate and a data transmission/reception unit of an automotive vehicle passing the tollgate to collect vehicle passage data, and prepares toll charge data from the vehicle passage data to automatically collect a road toll. According to an aspect of this invention, the data transmission/reception unit is a mobile terminal for mobile communication.

The mobile terminal may be adapted to transmit a radio signal carrying a terminal number assigned thereto and a predetermined dial number for a passage permission request. The tollgate may comprise a toll lane through which the automotive vehicle goes and an antenna over the toll lane which receives the radio signal transmitted from the mobile terminal. The tollgate further may comprises a processing unit for acquiring terminal information for identifying a user of the mobile terminal by accessing a mobile communication exchange system using the terminal number. The processing unit includes a data memory unit for storing passage vehicle information containing a passage time and the terminal information. The toll collection system further may comprise a central processing computer for obtaining from the processing unit the passage vehicle information together with tollgate information at least containing a tollgate identification code to prepare the toll charge data. The above-mentioned system utilizes the mobile terminal widely used in an ordinary telephone system. It is therefore unnecessary to provide the automotive vehicle with any special equipment in order to use the toll road. Thus, extra cost is saved.

Brief Description of the Drawing:

Fig. 1 is a functional block diagram for describing a toll collection system according to a first embodiment of this invention;

Fig. 2 is a flow chart for describing the operation of the system illustrated in Fig. 1 in preparation of passage car data;

Fig. 3 is a functional block diagram for describing a toll collection system according to a second embodiment of this invention; and

Fig. 4 is a flow chart for describing the operation of the system illustrated in Fig. 3 in preparation of toll charge data.

Description of the Preferred Embodiments:

Now, description will be made as regards an embodiment of this invention with reference to the drawing.

As well known in the art, toll collection systems for toll roads are classified into two types. A first type of the toll collection system is a uniform rate system where a toll is uniform independent of an interval of traveling and is determined on the basis of a vehicle's class alone. The vehicle's class defines a class of automotive vehicles. A second type of the toll collection system is a variable rate system where a toll is variable in dependence of the interval of traveling. In the variable rate system, tollgates are divided into two types, namely, entrance tollgates and exit tollgates. The uniform rate system will

be at first described. The variable rate system will later be described.

Referring to Fig. 1, a toll collection system according to a first embodiment of this invention is for collecting a toll from a user of an automotive vehicle 11 passing a tollgate on a toll road. The automotive vehicle 11 may be a light car, a minicar or a small-sized car, an ordinary class of car or an ordinary-sized car, a large-sized vehicle such as a bus, a truck or the like, an extra-large vehicle, and so on.

The toll collection system includes a plurality of toll lanes 12 (only one toll lane is illustrated), a terminal information receiving unit 13, a data memory unit 14, a central processing computer 15, and an interface circuit 16 connected to a mobile communication exchange system 30. The mobile communication exchange system 30 is connected to a communication network (not shown). When the automotive vehicle 11 passes through one of the toll lanes 12, the user of the automotive vehicle 11 has a mobile terminal 20 for mobile communication. The mobile terminal 20 may be a mobile telephone set, a portable telephone set, a personal handyphone, or the like. The data memory unit 14, the terminal information receiving unit 13, and the interface circuit 16 are included in a processing unit 17.

The toll collection system according to this invention is different from the conventional toll collection systems described in the preamble of the specification in the following respect. In this system, the mobile terminal 20 connected to the mobile communication exchange system 30 by means of radio waves serves to make a passage permission request when the automotive vehicle 11 passes the tollgate.

Each toll lane 12 extends straight and bears an indication of a particular dial number for use in making the passage permission request. The toll lane 12 is equipped with an antenna 121 for transmitting and receiving radio waves or radio signals to and from the mobile terminal 20,a vehicle's class detector 122 for detecting the vehicle's class, a signal unit 123, and a camera 124. The antenna 121 is located on a center line of each toll lane 12 extending straight.

In order to make the passage permission request, the user make the mobile terminal 20 off-hook. Thereby, the mobile terminal 20 transmits the radio signal carrying a terminal number assigned thereto. Thereafter, the user operates the mobile terminal 20 to dial the above-mentioned particular dial number preliminarily determined for selection of a toll collection system route. When the mobile terminal 20 originates a call by dialing the particular dial number, the mobile communication exchange system 30 is activated to start the operation of the toll collection system. Specifically, the particular dial number serves to establish a connection route between the mobile communication exchange system 30 and the terminal information receiving unit 13 of each tollgate. On the other hand, when any ordinary dial number is dialed, the mobile communication exchange system 30 is activated to start ordinary radio communication.

For example, the selection of the toll collection system route is represented by at least a first numerical character contained in the particular dial number. In this event, the mobile communication exchange system 30 judges from the first numerical character that the call is to be connected not to the communication network but to the toll collection system.

The antenna 121 serves to receive as a reception radio signal the above-mentioned call transmitted from the mobile terminal 20 and to supply the mobile communication exchange system 30 with a channel establishment request and the particular dial number via the interface circuit 16. On the other hand, the antenna 121 serves to transmit a transmission radio signal from the mobile communication exchange system 30. As will later be described, an entry lane which the automotive vehicle 11 is entering is detected with reference to a difference between signal levels of the same reception radio signal received at the toll lanes 12 adjacent to one another. In order to facilitate such detection, the antenna 121 is located on a center line of each toll lane 12 as mentioned before. Preferably, each antenna 12 is directional antenna which faces the toll lane 12 in question.

The vehicle's class detector 122 detects the vehicle's class of the automotive vehicle 11 passing the tollgate and supplies vehicle's class information indicative of the vehicle's class to the data memory unit 14. It is noted here that the vehicle's class is required in charging the toll for the toll road.

The vehicle's class detector 122 may be a number plate reader for reading a registration number on a number plate of the automotive vehicle 11 passing the tollgate and supplies, as the vehicle's class information, the registration number to the data memory unit 14. In the present status, however, the toll in relation to the vehicle's class is not always determined by the registration number alone. In view of the above, the vehicle's class for determination of the toll is preliminarily stored in a memory (not shown) of the central processing computer 15 in relation to the registration number.

The signal unit 123 has a function of detecting the passage of the automotive vehicle 11 to produce a passage detection signal on detection of the passage of the automotive vehicle 11. That is, the signal unit 123 serves as a passage detection unit. When all required information of the car 11 passing the tollgate is properly obtained, the signal unit 123 turns on a green light as a go signal in response to a passage permission signal from the processing unit 17. Simultaneously, the signal unit 123 notifies the camera 124 of the go signal and allows the passage of the automotive vehicle 11. At any rate, the signal unit 123 acts as a passage permission announcing unit for announcing passage permission to the user of the mobile terminal 20 in response to the passage permission signal. After the passage of the automotive vehicle 11, the signal unit 123 turns on a red light

as a stop signal. The signal unit 123 notifies the data memory unit 14 of the fact that the camera 124 performs a photographing operation during the stop signal as will be described below.

The camera 124 is operatively coupled with the signal unit 123. When the signal unit 123 indicates the go signal, the camera 124 performs no photographing operation. On the other hand, in presence of an illegal passage of the automotive vehicle 11 during the stop signal, the camera 124 is informed of the occurrence of the illegal passage from the signal unit 123. In this event, the camera 124 photographs a front side of the automotive vehicle 11 to identify a driver and informs the signal unit 123 of execution of the photographing operation. At any rate, the camera 124 is operable as a picking unit for picking up the automotive vehicle 11 on reception of the passage detection signal before reception of the passage permission signal.

The interface circuit 16 is connected to the mobile communication exchange system 30 which has a charge function to the mobile terminal 20. The interface circuit 16 is connected to the antenna 121 of each toll lane 12 and identifies as the entry lane one of the antennas 121 that receives the reception radio signal as a strongest radio wave from the mobile terminal 20 in the automotive vehicle 11. From the reception radio signal, the interface circuit 16 detects the terminal number of the mobile terminal 20 to send it to the mobile communication exchange system 30.

On one hand, the mobile communication exchange system 30 copes with various mobile communication systems. The interface circuit 16 acts as a lane identifying unit for identifying, as the entry lane, one of the toll lanes 12 that the automotive vehicle 11 go through to produce lane information indicative of the entry lane. However, the lane identifying unit may be omitted if the tollgate has only one toll lane 12. When the entry lane 12 is identified, the interface circuit 16 sends the lane information to the terminal information receiving unit 13.

On the other hand, the mobile communication exchange system 30 typically has an integrated data storage (not shown) which preliminarily stores subscriber data for use as terminal information. The subscriber data includes the name and the address of a payer as well as the manner of payment, in relation to the subscriber number or the terminal number of the mobile terminal 20. Responsive to the terminal number, the mobile communication exchange system 30 searches the terminal information identifying the user of the mobile terminal 20 in the integrated data storage. The terminal information is sent from the mobile communication exchange system 30 via the interface circuit 16 to the terminal information reception unit 13. In preparation of toll charge data corresponding to the charge function, the terminal information receiving unit 13 obtains from the mobile communication exchange system 30 via the interface circuit 16 the above-mentioned subscriber data as the terminal information with reference to the subscriber number or the terminal number of the mobile terminal 20. That is, the terminal information reception unit 13 serves in cooperation with the interface circuit 16 as an acquiring arrangement for acquiring the terminal information by accessing the mobile communication exchange system 30 using the terminal number.

The terminal information receiving unit 13 is equipped in each tollgate to receive from the mobile communication exchange system 30 via the interface circuit 16 the lane information and the terminal information for each toll lane and to transmit the lane information and the terminal information to the data memory unit 14.

The data memory unit 14 is supplied from the vehicle's class detector 122 with equipped lane information of a particular toll lane where the vehicle's class detector 122 is equipped and with the vehicle's class information detected by the vehicle's class detector 122. On the other hand, the data memory unit 14 receives the terminal information and the lane information from the terminal information receiving unit 13 as described above. The processing unit 17 collates the lane information with the equipped lane information to find coincidence therebetween. The processing unit 17 confirms the terminal information and the vehicle's class corresponding to the toll lane 12 of coincidence.

After the terminal information and the vehicle's class are confirmed, the processing unit 17 stores in the data memory 14, as passage vehicle information, the terminal information and the vehicle's class information together with a passage time. In addition, the processing unit 17 adds tollgate information to the passage vehicle information to prepare vehicle passage data for transmission to the central processing computer 15. On the other hand, the processing unit 17 sends the above-mentioned passage permission signal to the signal unit 123 of the toll lane 12 in consideration to turn on the green light. In case where the processing unit 17 is notified from the signal unit 123 of execution of the photographing operation, the processing unit 17 stores in the data memory unit 14, as abnormal passage vehicle. information, the passage time and photograph information together with the terminal information and the lane information already collected. Simultaneously, the abnormal passage vehicle information and the tollgate information are transmitted to the central processing computer 15 as the vehicle passage data.

The central processing computer 15 obtains the vehicle passage data from every tollgate. Inasmuch as the illustrated toll collection system is a uniform rate system, a particular tollgate defines a uniform or flat rate. In this event, the central processing computer 15 recognizes the collection of the uniform rate with reference to the name of the particular tollgate and the vehicle's class so that the toll charge data can be immediately prepared from the vehicle passage data of the particular tollgate and stored in the memory of the central processing computer 15. The toll charge data accumulated in the central processing computer 15 can be periodically read to pre-

pare a bill which is sent to the user.

In the foregoing, the vehicle's class is detected by the number plate reader as the vehicle's class detector in combination with vehicle's class data corresponding to the vehicle number. Alternatively, use may be made of a step board and an optical detector like in the prior art. In this event, the vehicle's class of the automotive vehicle entering the toll lane is detected with reference to the number of axles. It is therefore desired to temporarily stop the automotive vehicle.

Referring to Fig. 2 in addition to Fig. 1, description will be made as regards an operation of preparing the tollgate data transmitted from the tollgate.

At first, when the automotive vehicle 11 enters the toll lane 12 of the tollgate, the vehicle's class detector 122 detects the vehicle's class of the automotive vehicle 11 (step S1) and delivers the equipped lane information and the vehicle's class signal to the data memory unit 14. On the other hand, supplied with the call from the mobile terminal 20 through the antenna 121 and the interface circuit 16, the mobile communication exchange system 30 establishes a channel and transmits a dial tone to receive the passage permission request (step S2) and the interface circuit 16 identifies the toll lane 12 to produce the lane information (step S3). Simultaneously, the mobile communication exchange system 30 obtains the terminal information including the identification of the payer with reference to the terminal number contained in the call (step S4). The lane information and the terminal information are delivered to the data memory unit 14 through the terminal information receiving unit 13.

As mentioned above, the data memory unit 14 receives the equipped lane information and the vehicle's class signal from the vehicle's class detector 122 on one hand. On the other hand, the data memory unit 14 receives the lane information and the terminal information from the mobile communication exchange system 30 through the interface circuit 16 and the terminal information receiving unit 13.

For the lane information of coincidence, the processing unit 17 stores in the data memory unit 14, as the passage vehicle information, the terminal information and the vehicle's class signal together with the lane information and the passage time (step S5). On the other hand, the normality of the passage vehicle information thus memorized is checked (step S6).

When the passage vehicle information as stored is normal ("YES" in step S6), the processing unit 14 sends the passage permission signal to the signal unit 123 to switch the red light into the green light so as to allow the passage of the automotive vehicle 11 (step S7) and inhibits the photographing operation of the camera 124. Then, when the vehicle 11 passes the signal unit 123 (step S8), the processing unit 17 delivers a passage prohibition signal to the signal unit 123 to turn the green light back to the red light (step S9). In this event, the passage of any automotive vehicle is prohibited while the inhibition of the photographing operation by the camera 124 is cancelled. On the other hand, the passage vehicle information containing the lane information, the tollgate information, and the passage time are collectively delivered to the central processing computer 15 as the vehicle passage data (step S10).

If the passage vehicle information stored in the data memory unit 14 is abnormal ("NO" in step S6), the processing unit 17 notifies the user of the mobile terminal 20 (the automotive vehicle 11) that the passage permission request should be performed again (step S11). In this event, the signal unit 123 keeps the red light. When the automotive vehicle 11 advances to the position of the signal unit 123 ("NO" in step S12), the camera 124 performs the photographing operation in response to the instruction from the signal unit 123 and the abnormal passage vehicle information is stored in the data memory unit 14 (step S13). Then, the step S13 proceeds to the step S10.

When the automotive vehicle 11 is kept stopped because the signal unit 123 indicates the red light ("NO" in step S12), the operation returns to the step S2 in which the passage permission request is received.

Referring to Fig. 3, a toll collection system according to a second embodiment of this invention is similar in structure to that that illustrated in Fig. 1 except that the tollgate comprises a vehicle identification unit 122A in place of the vehicle's class detector 122.

In the toll collection system, the tollgate is used as an entrance tollgate or the an exit tollgate. The vehicle identification unit 122A identifies the automotive vehicle 11 to produce vehicle identification (ID) information. The vehicle identification unit 122A may be the number plate reader for reading, as the vehicle ID information, the registration number on the number plate of the automotive vehicle 11. The vehicle ID information indicates the vehicle number of the automotive vehicle 11.

Inasmuch as both the entrance tollgate and the exit tollgate are involved, the vehicle passage data from the entrance tollgate are stored as entrance data. With reference to the vehicle passage data received from the exit tollgate, the entrance data are searched for. With reference to the both data, calculation is made of the toll to prepare the toll charge data which are stored in the central processing computer 15.

Next referring to Fig. 4 in combination with Fig. 3, description will be made as regards an operation of preparing the toll charge data in case where a plurality of entrance tollgates and a plurality of exit tollgates are involved.

At first, the central processing computer 15 receives the vehicle passage data from the data memory unit 14 of each tollgate (step S21). When received from the entrance tollgate ("YES" in step S22), the central processing computer 15 stores the vehicle passage data as the entrance data (step S23) in a memory (not shown). If the entrance data thus received are abnormal ("YES" in step S24), an abnormal data processing operation is

carried out in a predetermined manner (step S25).

On the other hand, when the vehicle passage data are received from the exit tollgate ("NO" in step S22), the central processing computer 15 searches for the entrance data with reference to the vehicle number of the vehicle passage data received from the exit tollgate (step S31). Thus, the entrance data of the same vehicle number are related to the vehicle passage data received from the exit tollgate ("YES" in step S32). For those data, confirmation is made of the normality of the terminal information of the mobile terminal 20 which transmits the call. If the terminal information is normal without any abnormality ("NO" in step S33), the central processing computer 15 prepares the toll charge data for a subscriber of the mobile terminal 20 (step S34). On the other hand, when the terminal information has any abnormality ("YES" in step S33), the toll charge data are prepared for the vehicle number (step S35).

When the same vehicle number can not be found ("NO" in step S5), the central processing computer 15 recognizes the automotive vehicle 11 as an illegal passage vehicle and performs a predetermined operation (step S36).

In the foregoing, the subscriber data of the mobile terminal are described as a part of the charge function of the mobile communication exchange system and included in the terminal information delivered from the mobile communication exchange system. Alternatively, the subscriber data may be searched by the central processing computer in correspondence to the subscriber number or the terminal number delivered from the mobile communication exchange system.

In the foregoing, as far as the mobile communication exchange system can discriminate the call for the toll collection system, the lane identifying unit having a function equivalent to the antenna identifying function of the mobile communication exchange system is equipped in each tollgate together with the terminal information receiving unit. Alternatively, the antenna of the mobile communication exchange system may be equipped in each toll lane and the mobile communication exchange system may identify the toll lane in consideration.

In the foregoing, the operation in the abnormal condition is partially described with the remaining part omitted.

In the foregoing, a few embodiment have been described by way of example. However, this invention is not restricted to the above-described embodiments but includes various modifications by separation and combination of the functions, exchange of the order of the steps, performance of parallel operations, and so on.

In the above-mentioned toll collection systems according to this invention, the data transmission/ reception unit is implemented by the mobile terminal for mobile communication. Each toll lane is equipped with the antenna for receiving the terminal number and the predetermined dial number transmitted from the mobile terminal, and the vehicle's class detector for detecting the vehicle's class of the automotive vehicle entering the toll lane. Each tollgate is equipped with the processing unit supplied from the antenna with the radio signal carrying the dial number and the terminal number for identifying the entry lane of the automotive vehicle and for acquiring the terminal information. In addition, the processing unit is also supplied from the vehicle's class detector with the vehicle's class detected by the vehicle's class detector to obtain the vehicle's class information. The processing unit then prepares and stores in a data memory unit the passage vehicle information containing the passage time, the lane information, the terminal information, and the vehicle's class information. The central processing computer obtains the vehicle passage data including the passage vehicle information and the tollgate information from every tollgate to prepare the toll charge data.

Since the mobile terminal for mobile communication is used as the data transmission/reception unit for the toll collection system, the user of the automotive vehicle is not required to have any special terminal equipment in order to use the toll road. Furthermore, the vehicle's class detector for detecting the vehicle's class of the automotive vehicle entering the toll lane is used in addition. It is therefore possible to properly charge the toll to the user of the toll road.

While this invention has thus far been described in conjunction with a few preferred embodiments thereof, it will now be readily possible for those skilled in the art to put this invention into various other manners. For example, the toll collection system may be applicable to a parking space, or the like. In addition, the tollgate may comprise only one toll lane.

Claims

1. A toll collection system which transmits and receives radio waves between a tollgate and a data transmission/reception unit of an automotive vehicle (11) passing said tollgate to collect vehicle passage data, and which prepares toll charge data from said vehicle passage data to automatically collect a road toll, characterized in that said data transmission/reception unit is a mobile terminal (20) for mobile communication.

2. A toll collection system as claimed in claim 1, wherein said mobile terminal (20) transmits a radio signal carrying a terminal number assigned thereto and a predetermined dial number for a passage permission request.

3. A toll collection system as claimed in claim 2, wherein said tollgate comprises a toll lane (12) through which said automotive vehicle (11) goes and an antenna (121) over said toll lane (12) which

receives said radio signal transmitted from said mobile terminal (20).

4. A toll collection system as claimed in claim 3, wherein said tollgate further comprises a processing unit (17), connected to said antenna and a mobile communication exchange system (30) and supplied from said antenna with said radio signal, for acquiring terminal information identifying a user of said mobile terminal (11) by accessing said mobile communication exchange system (30) using said terminal number, said processing unit (17) including a data memory unit (14) for storing passage vehicle information containing a passage time and the terminal information.

5. A toll collection system as claimed in claim 4, wherein further comprises a central processing computer (15), connected to said processing unit, for obtaining from said processing unit the passage vehicle information together with tollgate information at least containing a tollgate identification code to prepare the toll charge data.

6. A toll collection system as claimed in claim 4, wherein said processing unit (17) produces a passage permission signal when said processing unit receives said passage permission request from said mobile terminal via said antenna, said tollgate further comprises a passage permission announcing unit (123), connected to said processing unit, for announcing passage permission to the user of said mobile terminal in response to the passage permission signal.

7. A toll collection system as claimed in claim 6, wherein said passage permission announcing unit is a signal unit (123).

8. A toll collection system as claimed in claim 6, wherein said tollgate further comprises:

a passage detection unit (123) for detecting passage of said automotive vehicle (11) to produce a passage detection signal on detection of the passage of said automotive vehicle; and pickup means (124), connected to said passage detection means and said processing unit, for picking up said automotive vehicle (11) on reception of the passage detection signal before reception of the passage permission signal.

9. A toll collection system as claimed in claim 3, wherein said tollgate further comprises a vehicle's class detector (122), mounted on the toll lane, for detecting a vehicle's class of said automotive vehicle entering said tollgate to produce vehicle's class information indicative of the vehicle's class.

10. A toll collection system as claimed in claim 9, wherein said tollgate further comprises a processing unit (17), connected to said vehicle's class detectors and a mobile communication exchange system, for acquiring terminal information identifying a user of said mobile terminal by accessing said mobile communication exchange system using said terminal number, said processing unit including a data memory unit (14) for storing passage vehicle information containing a passage time, the terminal information, and the vehicle's class information.

11. A toll collection system as claimed in claim 10, wherein further comprises a central processing computer (15), connected to said processing unit, for obtaining from said processing unit the passage vehicle information together with tollgate information at least containing a tollgate identification code to prepare the toll charge data.

12. A toll collection system as claimed in claim 10, wherein said processing unit produces a passage permission signal when said processing unit receives said passage permission request from said mobile terminal via said antenna, said tollgate further comprises a passage permission announcing unit (123), mounted on the toll lane and connected to said processing unit, for announcing passage permission to the user of said mobile terminal in response to the passage permission signal.

13. A toll collection system as claimed in claim 12, wherein said passage permission announcing unit is a signal unit (123).

14. A toll collection system as claimed in claim 12, wherein said tollgate further comprises :

a passage detection unit (123), mounted on said toll lane, for detecting passage of said automotive vehicle to produce a passage detection signal on detection of the passage of said automotive vehicle; and
a pickup unit (124), connected to said passage detection unit and said processing unit, for picking up said automotive vehicle on reception of the passage detection signal before reception of the passage permission signal.

15. A toll collection system as claimed in claim 3, wherein said tollgate further comprises a vehicle identification unit (122A) for identifying said automotive vehicle (11) to produce vehicle identification information.

16. A toll collection system as claimed in claim 15,

wherein said vehicle identification unit is a number plate reader (122A) for reading, as the vehicle identification information, a registration number on a number plate of said automotive vehicle.

17. A toll collection system as claimed in claim 15, wherein said tollgate further comprises a processing unit (17), connected to said antenna, said vehicle identification unit, and a mobile communication exchange system and supplied from said antenna with said radio signal, for acquiring terminal information identifying a user of said mobile terminal by accessing said mobile communication exchange system using said terminal number, said processing unit including a data memory unit (14) for storing passage vehicle information containing a passage time, the vehicle identification information, and the terminal information.

18. A toll collection system as claimed in claim 17, wherein further comprises a central processing computer (15), connected to said processing unit, for obtaining from said processing unit the passage vehicle information together with tollgate information at least containing a tollgate identification code to prepare the toll charge data.

19. A toll collection system as claimed in claim 17, wherein said processing unit produces a passage permission signal when said processing unit receives said passage permission request from said mobile terminal via said antenna, said tollgate further comprises a passage permission announcing unit (123), connected to said processing unit, for announcing passage permission to the user of said mobile terminal in response to the passage permission signal.

20. A toll collection system as claimed in claim 19, wherein said passage permission announcing unit is a signal unit (123).

21. A toll collection system as claimed in claim 19, wherein said tollgate further comprises:

a passage detection unit (123) for detecting passage of said automotive vehicle to produce a passage detection signal on detection of the passage of said automotive vehicle; and
a pickup unit (124), connected to said passage detection unit and said processing unit, for picking up said automotive vehicle on reception of the passage detection signal before reception of the passage permission signal.

22. A toll collection system as claimed in claim 2, wherein said tollgate comprises a plurality of toll lanes (12) through one of which said automotive vehicle goes and a plurality of antennas (121) over the respective toll lanes each of which receives said radio signal transmitted from said mobile terminal.

23. A toll collection system as claimed in claim 22, wherein said antennas are directional antennas which face the respective toll lanes.

24. A toll collection system as claimed in claim 22, wherein said tollgate further comprises vehicle's class detectors mounted on the respective toll lanes, each of said vehicle's class detectors being for detecting a vehicle's class of said automotive vehicle entering said tollgate to produce vehicle's class information indicative of the vehicle's class.

25. A toll collection system as claimed in claim 24, wherein said tollgate further comprises a processing unit (17) connected to said vehicle's class detectors and a mobile communication exchange system, said processing unit comprising:

lane identifying means (16) for identifying, in response to said radio signal received by said antennas, one of said toll lanes that said automotive vehicle go through as an entry lane, said lane identifying means producing lane information indicative of the entry lane;
acquiring means (16, 13) for acquiring terminal information identifying a user of said mobile terminal by accessing said mobile communication exchange system using said terminal number; and
a data memory unit (14) for storing passage vehicle information containing a passage time, the lane information, the terminal information, and the vehicle's class information.

26. A toll collection system as claimed in claim 25, wherein further comprises a central processing computer (15), connected to said processing unit, for obtaining from said processing unit the passage vehicle information together with tollgate information at least containing a tollgate identification code to prepare the toll charge data.

27. A toll collection system as claimed in claim 25, wherein said processing unit produces a passage permission signal when said processing unit receives said passage permission request from said mobile terminal via said antennas, said tollgate further comprises a plurality of passage permission announcing units (123) mounted on the respective toll lanes and connected to said processing unit, each of said passage permission announcing units announcing passage permission to the user of said mobile terminal in response to the passage permission signal.

28. A toll collection system as claimed in claim 27, wherein each of said passage permission announcing units is a signal unit (123).

29. A toll collection system as claimed in claim 27, wherein said tollgate further comprises:

a plurality of passage detection units (123), mounted on the respective toll lanes, each of which detects passage of said automotive vehicle to produce a passage detection signal on detection of the passage of said automotive vehicle; and
a plurality of pickup units (124), connected to the respective passage detection units and said processing unit, each of which picks up said automotive vehicle on reception of the passage detection signal before reception of the passage permission signal.

30. A toll collection system as claimed in claim 22, wherein said tollgate further comprises a plurality of vehicle identification units (122A) mounted on the respective toll lanes, each of said vehicle identification units being for identifying said automotive vehicle to produce vehicle identification information.

31. A toll collection system as claimed in claim 30, wherein each of said vehicle identification units is a number plate reader (122A) for reading, as the vehicle identification information, a registration number on a number plate of said automotive vehicle.

32. A toll collection system as claimed in claim 30, wherein said tollgate further comprises a processing unit (17) connected to said vehicle identification units and a mobile communication exchange system, said processing unit comprising:

lane identifying means (16) for identifying, in response to said radio signal received by said antennas, one of said toll lanes that said automotive vehicle go through as an entry lane, said lane identifying means producing lane information indicative of the entry lane;
acquiring means (16, 13) for acquiring terminal information identifying a user of said mobile terminal by accessing said mobile communication exchange system using said terminal number;
a data memory unit (14) for storing passage vehicle information containing a passage time, the lane information, the terminal information, and the vehicle identification information.

33. A toll collection system as claimed in claim 32, wherein further comprises a central processing computer (15), connected to said processing unit, for obtaining from said processing unit the passage vehicle information together with tollgate information at least containing a tollgate identification code to prepare the toll charge data.

34. A toll collection system as claimed in claim 32, wherein said processing unit produces a passage permission signal when said processing unit receives said passage permission request from said mobile terminal via said antennas, said tollgate further comprises a plurality of passage permission announcing units (123) mounted on the respective toll lanes and connected to said processing unit, each of said passage permission announcing units announcing passage permission to the user of said mobile terminal in response to the passage permission signal.

35. A toll collection system as claimed in claim 34, wherein each of said passage permission announcing units is a signal unit (123).

36. A toll collection system as claimed in claim 34, wherein said tollgate further comprises:

a plurality of passage detection units (123), mounted on the respective toll lanes, each of which detects passage of said automotive vehicle to produce a passage detection signal on detection of the passage of said automotive vehicle; and
a plurality of pickup units (124), connected to the respective passage detection units and said processing unit, each of which picks up said automotive vehicle on reception of the passage detection signal before reception of the passage permission signal.

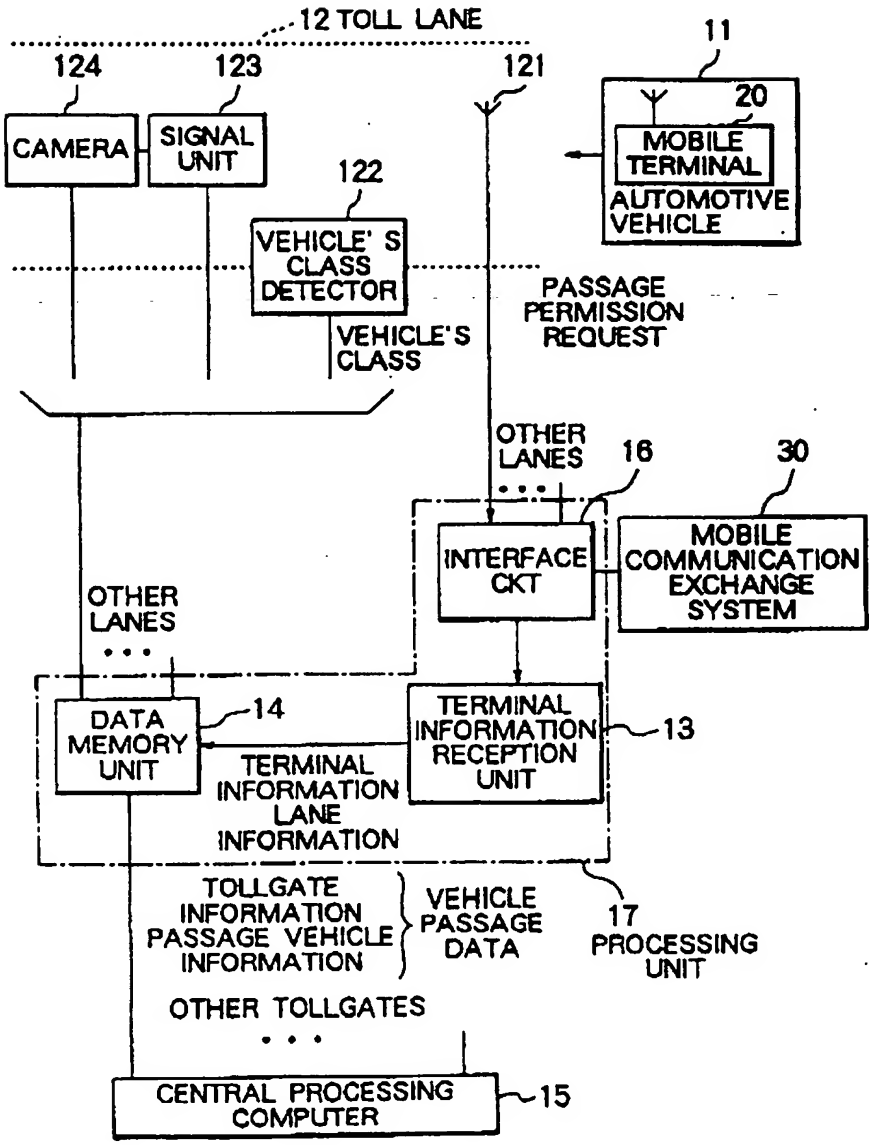
12 TOLL LANE
11
124
123
121
20
CAMERA
SIGNAL UNIT
MOBILE TERMINAL
AUTOMOTIVE VEHICLE
122
VEHICLE' S CLASS DETECTOR
PASSAGE PERMISSION REQUEST
VEHICLE'S CLASS
OTHER LANES
16
30
INTERFACE CKT
MOBILE COMMUNICATION EXCHANGE SYSTEM
OTHER LANES
DATA MEMORY UNIT
14
TERMINAL INFORMATION RECEPTION UNIT
13
TERMINAL INFORMATION LANE INFORMATION
TOLLGATE INFORMATION PASSAGE VEHICLE INFORMATION
VEHICLE PASSAGE DATA
17
PROCESSING UNIT
OTHER TOLLGATES
CENTRAL PROCESSING COMPUTER
15

FIG. 1

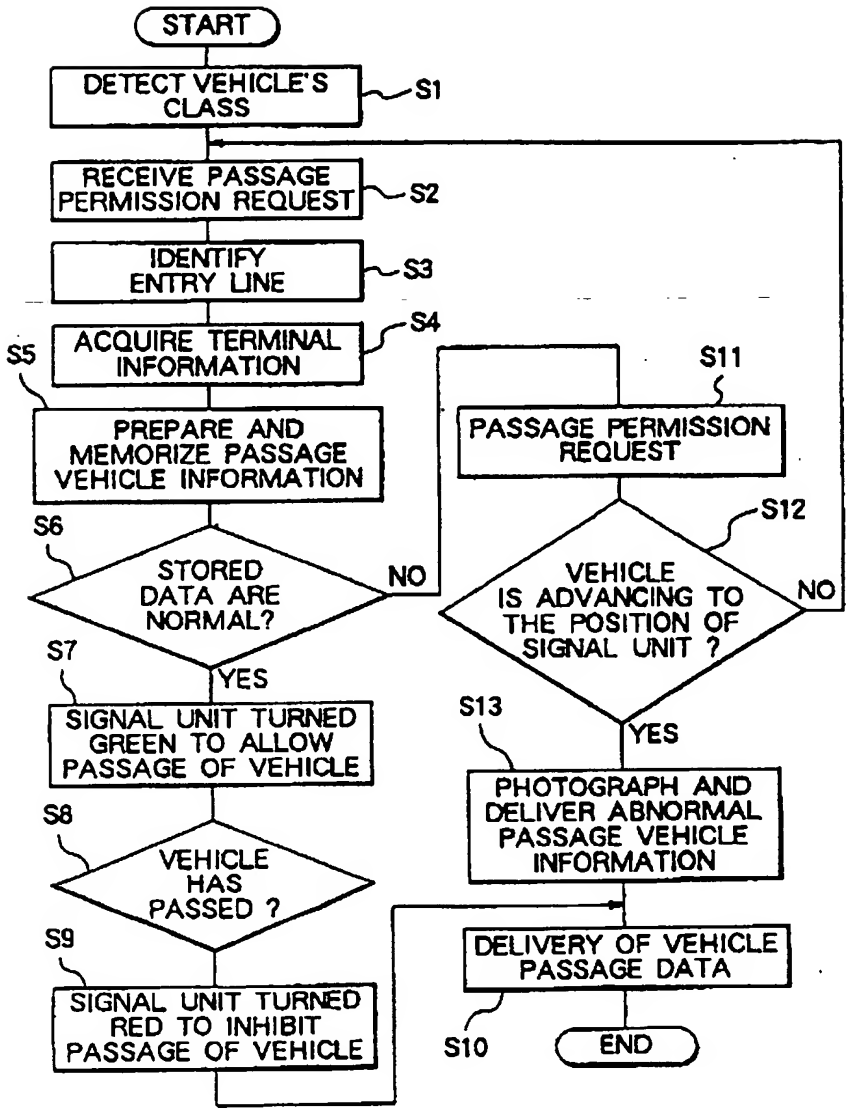
START
DETECT VEHICLE'S CLASS
S1
RECEIVE PASSAGE PERMISSION REQUEST
S2
IDENTIFY ENTRY LINE
S3
ACQUIRE TERMINAL INFORMATION
S4
S5
PREPARE AND MEMORIZE PASSAGE VEHICLE INFORMATION
S6
STORED DATA ARE NORMAL?
NO
YES
S7
SIGNAL UNIT TURNED GREEN TO ALLOW PASSAGE OF VEHICLE
S8
VEHICLE HAS PASSED ?
S9
SIGNAL UNIT TURNED RED TO INHIBIT PASSAGE OF VEHICLE
S11
PASSAGE PERMISSION REQUEST
S12
VEHICLE IS ADVANCING TO THE POSITION OF SIGNAL UNIT ?
NO
YES
S13
PHOTOGRAPH AND DELIVER ABNORMAL PASSAGE VEHICLE INFORMATION
DELIVERY OF VEHICLE PASSAGE DATA
S10
END

FIG. 2

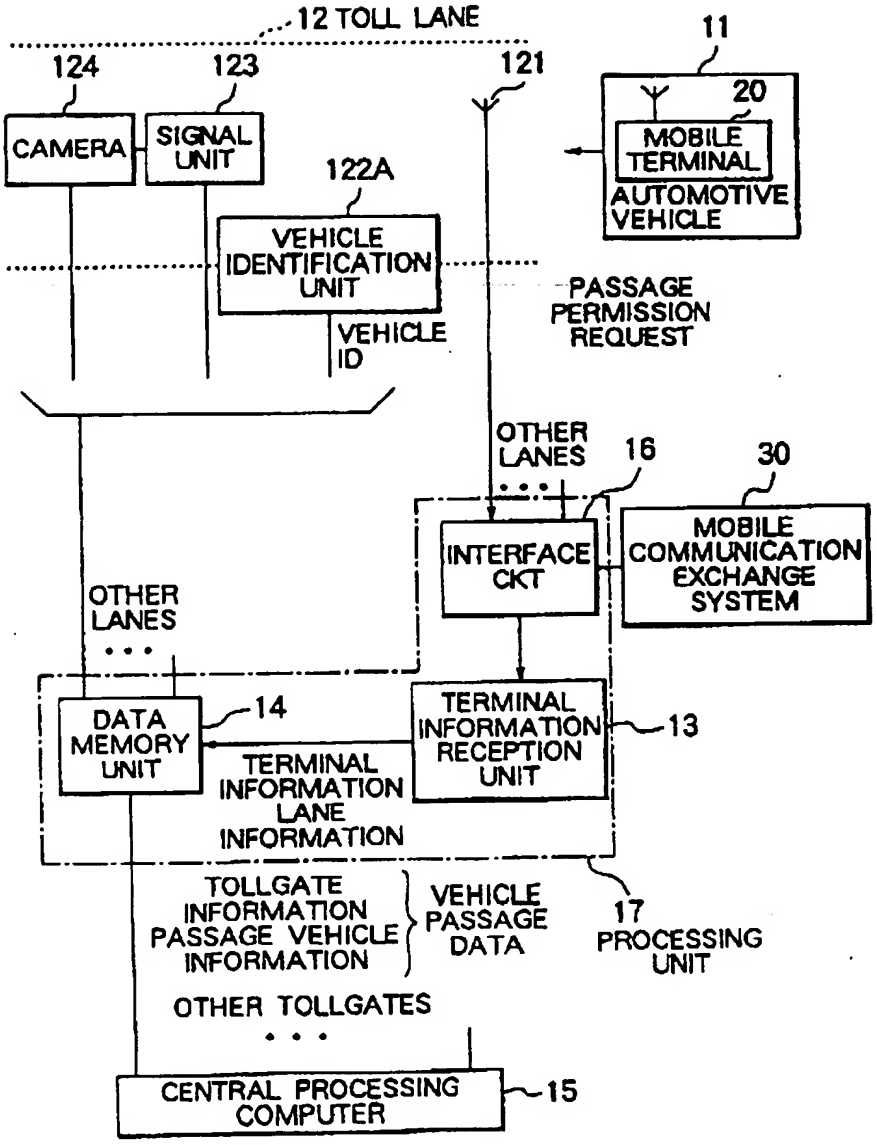
12 TOLL LANE
11
124
123
121
20
CAMERA
SIGNAL UNIT
MOBILE TERMINAL
AUTOMOTIVE VEHICLE
122A
VEHICLE IDENTIFICATION UNIT
PASSAGE PERMISSION REQUEST
VEHICLE ID
OTHER LANES
16
30
INTERFACE CKT
MOBILE COMMUNICATION EXCHANGE SYSTEM
OTHER LANES
DATA MEMORY UNIT
14
TERMINAL INFORMATION RECEPTION UNIT
13
TERMINAL INFORMATION
LANE INFORMATION
TOLLGATE INFORMATION
PASSAGE VEHICLE INFORMATION
VEHICLE PASSAGE DATA
17
PROCESSING UNIT
OTHER TOLLGATES
CENTRAL PROCESSING COMPUTER
15

FIG. 3

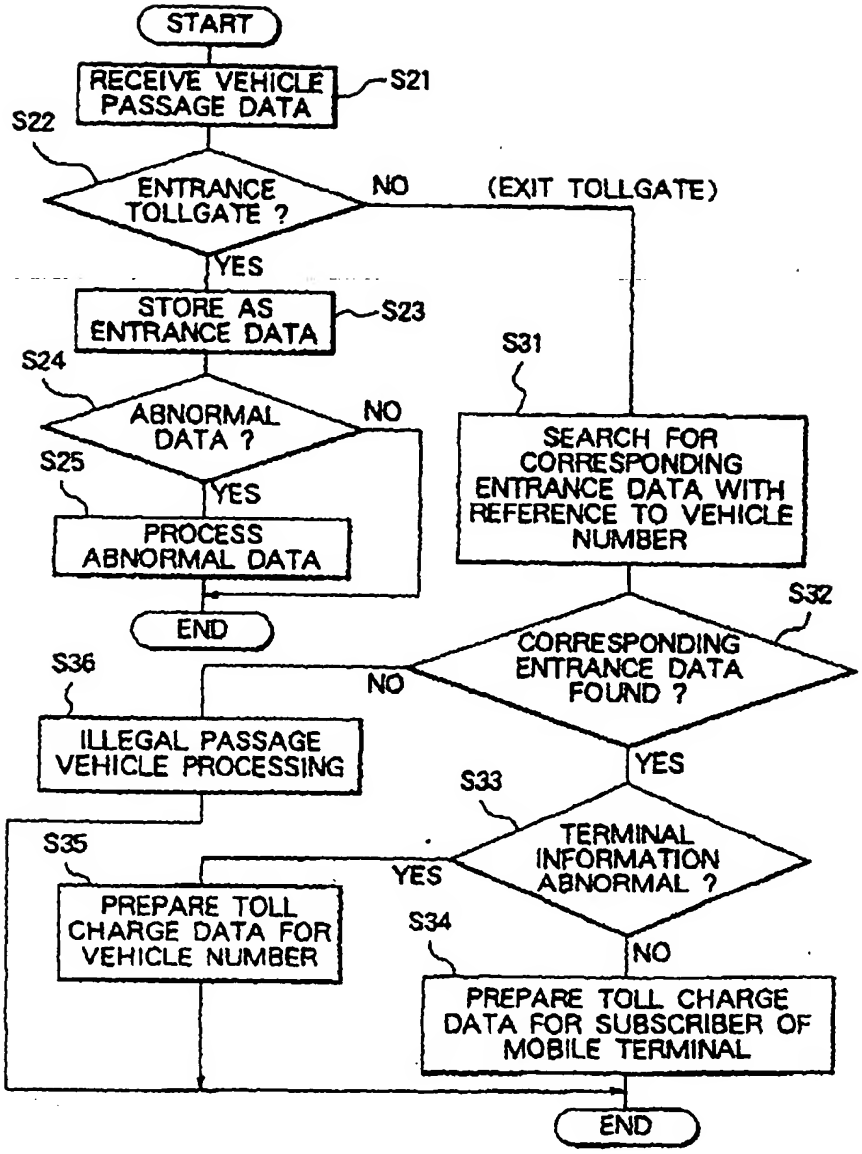
START
RECEIVE VEHICLE PASSAGE DATA
S21
S22
ENTRANCE TOLLGATE ?
NO
(EXIT TOLLGATE)
YES
STORE AS ENTRANCE DATA
S23
S24
ABNORMAL DATA ?
NO
S25
YES
PROCESS ABNORMAL DATA
END
S31
SEARCH FOR CORRESPONDING ENTRANCE DATA WITH REFERENCE TO VEHICLE NUMBER
S32
CORRESPONDING ENTRANCE DATA FOUND ?
NO
YES
S36
ILLEGAL PASSAGE VEHICLE PROCESSING
S33
TERMINAL INFORMATION ABNORMAL ?
YES
S35
PREPARE TOLL CHARGE DATA FOR VEHICLE NUMBER
S34
NO
PREPARE TOLL CHARGE DATA FOR SUBSCRIBER OF MOBILE TERMINAL
END

FIG. 4